Measurements and classification of Arabidopsis mutants exhibiting differences in the phyllotactic pattern.

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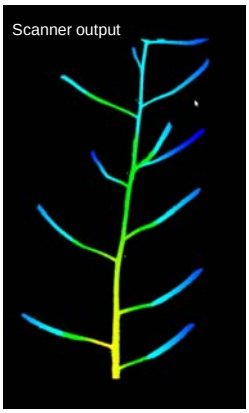
1. Automated measurements of divergence angles of plant organs using a commercial 3D scanner:

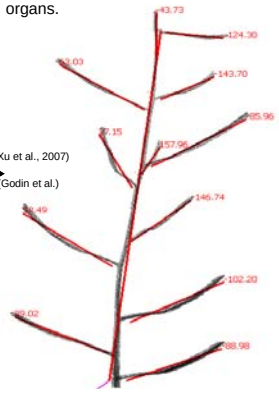
Scanner output



Skeletonization (Xu et al., 2007)

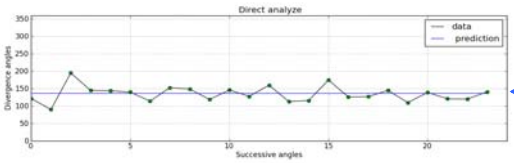
Convert to MTG (Godin et al.)

Automated extraction of divergence angles of organs.



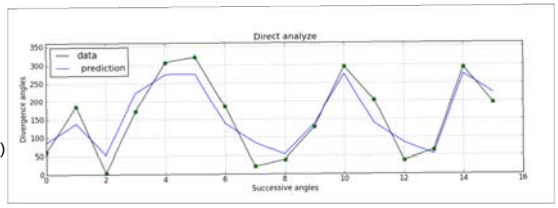
3. Detecting alterations to the phyllotactic pattern:

WT



← 137.5

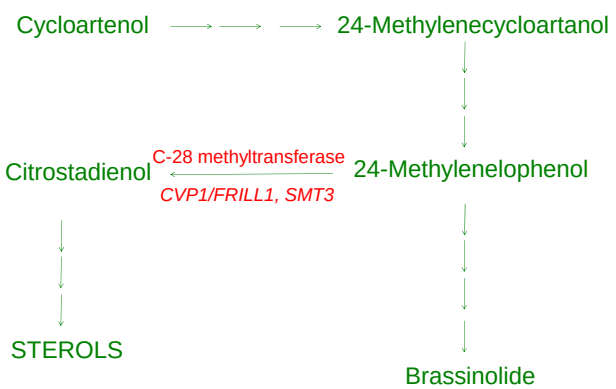
cvp1 (sterol mutant)



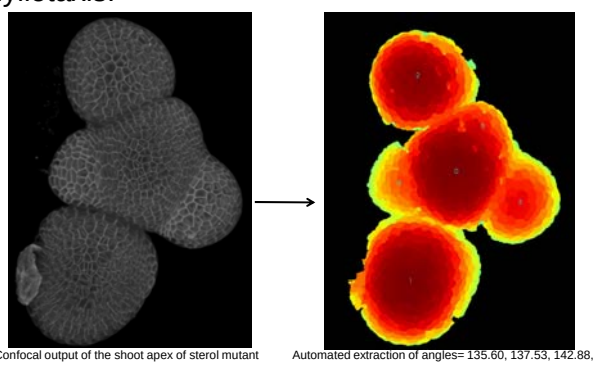
Measured angles were plotted and analysed as described by Refahi *et al*. 2010. Whereas WT angles are close to the golden angle of 137.5 degrees, sterol depletion in *cvp1* results in permutations in the phyllotactic pattern that result from a chain of inversions in organ order as you proceed up the stem.

2. Depletion of plant sterols result in permutations within the phyllotactic sequence:

- We have examined single and double *Arabidopsis* mutants of the C-28 methyltransferases involved in sterol synthesis.
- Sterol depletion in these mutants were observed to have a perturbed phyllotactic pattern.
- 3D scanning coupled with analysis of organ divergence angles and confocal microscopy have been used to help elucidate the role of plant sterols in phyllotaxis.



4. Correlative 3D scanning with confocal imaging of the shoot apex yields clues as to how sterols affect phyllotaxis:

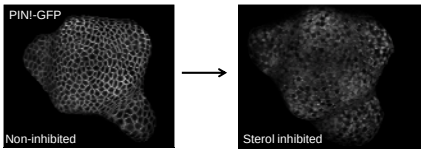


Confocal output of the shoot apex of sterol mutant

Automated extraction of angles= 135.60, 137.53, 142.88, 132.27

Using curvature values on the surface of the meristem and organ primordia, we can automatically identify the primordia and use this to extract angle measurements. Consistent with phyllotactic pattern resulting from permutations, sterol depletion has no effect upon the angles at which new organ primordia emerge, however, preliminary data suggest changes in relative growth rates of new organs. This may explain the pattern of permutations in the mutant plants.

We are currently working on the hypothesis that sterol depletion affects auxin transport by altering the membrane environment of the *PIN1* efflux carrier. Consistent with this, potent inhibition of the biosynthetic pathway to 24-methylenelophenol results in PIN1-GFP internalization but has no effect on other types of membrane protein:



Xu H, Gossett N, Chen B. 2007. Knowledge and Heuristic based Modeling of Laser Scanned Trees. ACM Transactions on Graphics 26:19:1 19:13. C Godin, E Costes, H Sinoquet A method for describing plant architecture which integrates topology and geometry 1999. Annals Botany Volume 84, Issue 3, 343-357. Yassin Refahi, Etienne Farcot, Yann Guédon, Fabrice Besnard, Teva Vernoux, Christophe Godin, A combinatorial model of phyllotaxis perturbations in Arabidopsis thaliana. Lecture Notes in Computer Science Volume 6661, 2011, pp 323-335